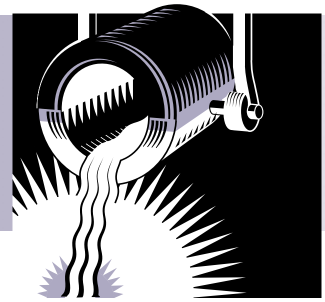
METAL CASTING

Project Fact Sheet



Heat Transfer at Mold/Metal Interface in Permanent Mold Casting of Aluminum Alloys

Benefits

This project will produce a number of benefits in permanent mold casting. Specific benefits include:

- Advances design technology for permanent mold casting
- Enables production of thinner wall, higher strength castings
- Improves reliability in production process and quality of final cast component
- Increases yield and reduces scrap
- Reduces energy consumption and emissions via reduced melting requirements resulting from yield/scrap improvements

Applications

The results of this can be applied throughout the permanent mold aluminum casting industry. In particular, they can be applied to the production of thinner wall, lighter weight, high strength, low cost castings. It will expand and open new markets for permanent mold castings in the transportation and other sectors.

Understanding of interfacial heat transfer improves energy efficiency and design precision

The design of aluminum alloy castings produced by the permanent mold casting process will be markedly improved. Heat transfer between a solidifying casting and mold is critical for achievement of a high quality casting. This is especially important in permanent mold casting where the heat transfer between the casting and the mold are primarily controlled by conditions at the mold-metal interface. The mold-metal interface is being emphasized in this project because the casting tends to shrink as it solidifies, creating areas where gaps form between the casting and the mold surface. Quantification of these conditions is key to understanding the permanent mold casting process and optimizing the casting process.

Research being conducted at the University of Michigan is evaluating heat transfer between the mold and the casting in permanent mold casting of aluminum alloys. It is developing a better understanding of the fundamentals of the process, in particular, interfacial heat transfer including the influence of gap formation and mold coatings, the stress and deformation of the solidifying casting, and the thermal and mechanical behavior of the mold. Understanding of these parameters will enable more precise casting designs and will save energy through improvements in casting yield. Researchers will perform experimental measurements of the above fundamental parameters in order to provide foundries with a means to define and predict multidimensional heat flow in permanent mold casting. These designs will allow production of castings with closer tolerances, improved properties, higher integrity, and lower weight.

Solidification Simulation of Sample Castings

Low Pressure Permanent Mold Casting | Squeeze Casting

Low pressure permanent mold casting solidification time ranges 33 to 232 seconds; squeeze casting ranges 3.9 to 47.2 seconds.

Project Description

Goal: Objectives of this project are:

- Model and simulate the 3D solidification process of squeeze cast and Low Pressure PM cast aluminum alloys.
- Design and implement experiments to estimate interfacial heat transfer coefficient values for squeeze casting and LPPM casting processes.
- Conduct a metallographic study to arrive at SDAS vs. local cooling rate correlation for both the casting processes.
- Show experimental results and compare simulated results with experiments.
- Develop a database for Heat Transfer Coefficient (HTC) evaluation in PM casting.

Progress and Milestones

This three year project was awarded in September 1997. Specific tasks include:

- Computer Modeling - This will involve modeling and simulation of mold filling. Tasks include:
  - Solidification modeling
  - Modeling of mold filling
  - Solving of multi-dimensional inverse heat conduction problems
  - Analyze interfacial heat transfer
  - Model boundary conditions
  - Create a database for modeling of permanent mold castings
- Experimental Program - This will involve pouring aluminum alloys as permanent mold castings of moderate complexity. Tasks include:
  - Thermal monitoring
  - Pressure monitoring
  - Analyze impacts of process variables on aluminum alloy casting quality
  - Investigate casting geometries
  - Metallographic inspection of casting

Accomplishments

- In an attempt to develop a Heat Transfer Coefficient (HTC) evaluator, a user-friendly program was designed and developed on the Windows platform to help foundry engineers choose appropriate HTC values for a particular casting process.
- Experiments were designed and conducted with temperature and in-cavity pressure sensing for a better understanding of the indirect squeeze casting process.
- Interfacial Heat Transfer Coefficient (IHTC) has been estimated for indirect squeeze casting of A356 alloys by 3D simulation of the casting process.
- SDAS vs. local solidification rate relationship for squeeze cast A356 alloys is found to be different from what is reported in the literature. A smaller SDAS for the modified alloy is predicted.
- A novel approach to estimating interfacial HTC in Low Pressure Permanent Mold (LPPM) casting has been developed and experimentally verified. The method takes into account the spatial and temporal variations of the IHTC.
- Influence of air gap formation and mold coatings in controlling interfacial heat transfer in a LPPM casting process is identified.

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